Feature Story

Trash to Treasure:
Landfills as an energy resource

Rachel Goldstein, Program Manager, Landfill Methane Outreach Program, U.S. Environmental Protection Agency

Most people don't think of landfills as much more than a necessary evil at best, a community liability at worst. However, society's current primary method of waste management produces a byproduct with a significant energy value: landfill gas. A landfill can provide a valuable, lower-cost supply of energy that is also considered 'green' in many places. Corporations, utilities and governments are increasingly recognizing landfill gas for its many benefits.

Putting Landfill Gas to Work

Landfill gas naturally results from the decomposition of organic waste in landfills and is comprised primarily of methane – the main component of natural gas – and carbon dioxide. Instead of being allowed to escape into the air, landfill gas can be captured, converted and used as an energy source. Using landfill gas has multiple benefits. It reduces odors and other hazards associated with landfill gas emissions, such as local air pollution from the volatile organic compounds in the gas or subsurface gas migration. It also prevents methane from migrating into the atmosphere and contributing to local smog and global climate change. (Methane is a potent greenhouse gas – about 21 times more so than CO_2.)

Landfill gas is extracted from landfills using a series of wells and a blower/flare (or vacuum) system. This system directs the collected gas to a central point where it can be processed and treated depending on the ultimate use for the gas. From this point, the gas can be simply flared or used to generate electricity, replace fossil fuels in industrial manufacturing and district energy operations, fuel greenhouse operations or be upgraded to pipeline-quality gas.

The U.S. Environmental Protection Agency's Landfill Methane Outreach Program (LMOP), which helps various communities and organizations develop landfill-gas-to-energy projects, has seen a dramatic increase in the use of landfill gas as an energy source in the U.S. over the past 10 years. Nearly all of these applications have had some contact or involvement with LMOP. There are currently 396 projects on line in the U.S. alone and more than 1,100 worldwide (most of these international projects are

In the U.S., nearly 400 landfills such as this one are currently being tapped to supply landfill gas for use as a fuel in power production, district energy systems and other applications.

Reprinted from Third Quarter 2006 District Energy magazine with permission of IDEA.

not LMOP-assisted). While this number is impressive, there is still a long way to go. There are still at least 600 U.S. landfills that could economically support a project. These 600 landfills would have a generation capacity of more than 1,400 MW or could supply 356 billion cu ft per year of gas to industrial end-users.

The generation of electricity from landfill gas makes up about two-thirds of the currently operational projects in the United States. Electricity for on-site use, district energy system use or sale to the grid can be generated using a variety of different technologies, including internal combustion engines, turbines, microturbines, Stirling engines (external combustion engines) and Organic Rankine Cycle engines. The vast majority of projects use internal combustion engines or turbines, with microturbine technology being used at smaller landfills and in niche applications. Electricity generation that is not for the grid will often utilize combined heat and power. Directly using landfill gas to offset the use of another fossil fuel is occurring in about one-third of the currently operational projects. This direct use of landfill gas can be in a boiler (e.g. district energy), dryer, kiln, greenhouse or other thermal applications.

Although landfill gas is widely used as fuel to produce electricity and fire boilers, there are differences between using landfill gas and natural gas in these applications. Unlike natural gas, landfill gas is normally saturated with moisture and carries varying quantities of compounds that contain sulfur, chlorine and silicon. Although the constituents in the gas have not deterred successful landfill gas use in a large number of utilization projects, they do need to be considered in project planning.

Landfill gas systems typically require bulk moisture removal, refrigerated drying and dew-point suppression through a reheat cycle. Moisture removal from the landfill gas is generally greater than 90 percent, depending on the technology used. A method for removal of contaminants, including non-methane organic compounds (NMOCs) and siloxanes, is generally also recommended. Combustion turbines and reciprocating engines have operated with no provisions for contaminant removal. Although there is an increasing list of siloxane and contaminant removal technologies available, carbon adsorption is still the only proven and cost-effective method.

Market Drivers

In the past two years, LMOP has seen increasing interest in utilizing landfill gas, particularly to offset fossil fuel consumption. The interest is fueled by both economic and environmental factors. Energy costs in general have been rising, and energy markets are becoming increasingly volatile. At the time of this writing, the Henry Hub and NYMEX indicators showed the price of natural gas at just over $7/MMBtu, down from $13/MMBtu a few months prior.

Higher prices not only encourage energy users to look for less expensive sources, but they also make project economics more attractive. A perfect example is that high energy prices are making longer pipeline projects not only possible but profitable. Five years ago, a pipeline project was generally thought to be economically feasible at five miles or less. In 2003, however, BMW Manufacturing developed a landfill gas project at its South Carolina plant that involved the construction of a 10-mile pipeline. In 2004, a Honeywell landfill gas project came on line with a 23-mile pipeline – the longest in the U.S.!

Industrial operations and governments are realizing significant energy cost savings when they use landfill gas. BMW notes that it saves more than $1.0 million per year at its South Carolina plant alone, where it is using landfill gas to generate electricity and capturing waste heat from the turbines for plant operations. The National Aeronautics and Space Administration, the first federal facility to use landfill gas, saves more than $350,000 per year by using landfill gas in place of natural gas in its Maryland flight center district heating system (fig. 1; also see sidebar on p.---). Prompted by rising energy costs, the University of New Hampshire is also exploring the feasibility of a landfill gas project. The gas would be transported through a 13-mile pipeline for heat and electricity at the university's cogeneration plant.

> NASA saves more than $350,000 per year by using landfill gas in its Maryland flight center district heating system.

Economic benefits are certainly a powerful motivator, but environmental

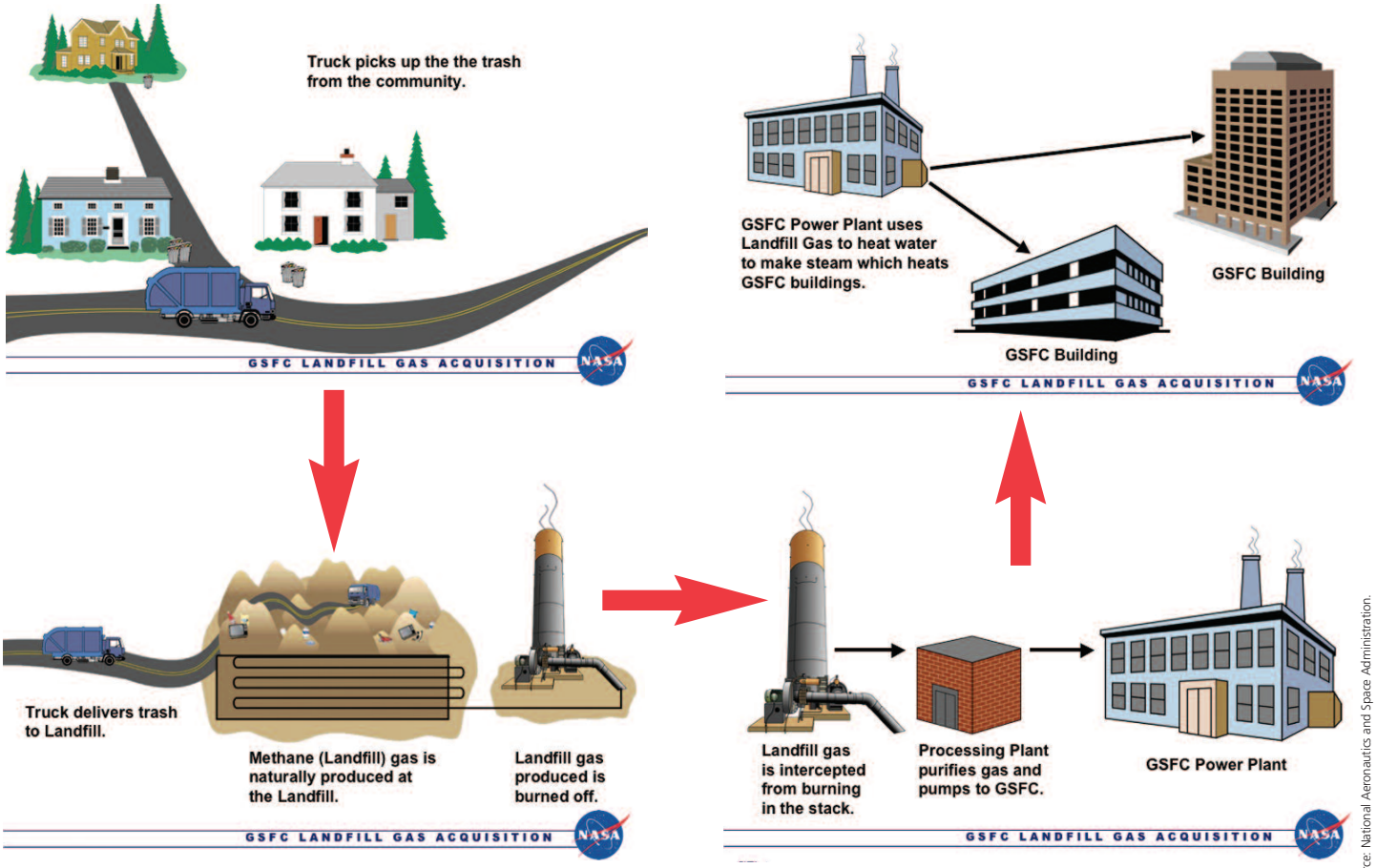
Overcoming Barriers: EPA's Landfill Methane Outreach Program

The U.S. Environmental Protection Agency understands the importance of controlling landfill gas emissions while at the same time realizing the potential for beneficial use. In 1994 the EPA created the Landfill Methane Outreach Program (LMOP). LMOP is a voluntary assistance program that helps reduce methane emissions from landfills by encouraging the recovery and use of landfill gas as an energy resource.

LMOP forms partnerships with communities, landfill owners, utilities, power marketers, states, project developers, tribes and nonprofit organizations to overcome barriers to development of landfill-gas-to-energy projects. LMOP does so by helping these groups assess project feasibility, find financing and market the benefits of a project to the community.

To read more about the program, go to www.epa.gov/lmop.

Figure 1. Landfill-Gas-to-Energy Use in NASA's Goddard Space Flight Center's Landfill Gas and District Energy System, Prince George's County, Md.



Source: National Aeronautics and Space Administration.

stewardship and corporate social responsibility are also strong market drivers for landfill gas projects. Good corporate citizens are joining voluntary greenhouse gas reduction programs such as the EPA's Climate Leaders program and the Chicago Climate Exchange®. Climate Leaders is an industry-government partnership that works with companies to develop long-term comprehensive climate change strategies. The Chicago Climate Exchange is a greenhouse gas emission reduction and trading program for emission sources and offset projects in the U.S., Canada and Mexico. Local municipalities and universities have also joined the Chicago Climate Exchange.

Additional market drivers, particularly for electricity generation, include the recent energy bill. The Energy Policy Act of 2005 has the Section 45 Production Tax Credit, which applies to landfill gas. The tax credit is worth 0.9 cents/kWh for electricity produced from landfill gas. Piping gas to another location for non-grid generation and CHP is included;

LMOP Goes Global: Methane to Markets

The success of the EPA's domestic Landfill Methane Outreach Program led the agency to develop Methane to Markets, an international methane reduction initiative launched in November 2004. This action-oriented effort focuses on cost-effective, near-term methane recovery and use as a clean energy source – to be accomplished through the collaboration of developed countries, developing countries and countries with economies in transition, together with strong private-sector participation.

To date, the Methane to Markets Partnership consists of 17 member countries. Their shared goal is to reduce global methane emissions to enhance economic growth, promote energy security, improve the environment and reduce greenhouse gases. Other benefits of the partnership include improving mine safety, reducing waste and improving local air quality. In its work, Methane to Markets targets four major methane sources: landfills, underground coal mines, natural gas and oil systems, and agriculture.

For more information, see www.methanetomarkets.org.

Reprinted from Third Quarter 2006 District Energy magazine with permission of IDEA.

Landfill-Gas-to-Energy Project Examples

University of California, Los Angeles

Project System Information

- 4.5-mile pipeline delivers medium-Btu (500-Btu/scf) gas to UCLA from Mountaingate Landfill.
- Includes two 14.5 MW combustion turbine generators fueled by 65% natural gas/35% landfill gas and one condensing steam turbine electric generator.
- Heat capacity: 234 MMBtu/hr.
- Electric capacity: 43 MW.
- Started 1984 (pre-dating LMOP).

Project Impact/Benefits

- Saves $250,000 annually in natural gas purchases.
- Provides 85% of UCLA's electricity needs.
- Won IDEA's System of the Year Award, 1997.

Source: U.S. Environmental Protection Agency, Landfill Methane Outreach Program. Includes information compiled from the California Energy Commission, IDEA and NST Engineers.

NASA's Goddard Space Flight Center (GSFC) Prince George's County, Md.

Project System Information

- First federal facility in the country to implement a landfill gas energy project.
- Two of five boilers at GSFC district heating plant were modified to run on landfill gas and can use natural gas or fuel oil as backup.
- Landfill gas is supplied from nearby Prince George's County-owned Sandy Hill landfill and fuels two boilers to make steam that circulates to heat GSFC buildings.
- An LMOP-assisted project.

Project Impact/Benefits

- Illustrates a successful public-private partnership between Prince George's County Waste Management, Toro Energy, NASA and LMOP.
- Saves an estimated $350,000 per year in energy costs.

Source: U.S. Environmental Protection Agency, Landfill Methane Outreach Program.

Pacific Palms Resort City of Industry, Calif.

Project System Information

- Pacific Palms Resort includes two golf courses, a conference center, Olympic-sized pool, tennis complex, equestrian center, laundry facility and hotel.
- Landfill gas is supplied by the Industry Hills Landfill, which is owned by the City of Industry and located on resort property.
- First phase: In 1980 a medium-Btu landfill-gas-to-energy project was installed for convention center boilers and water heaters for pool and laundry.
- Second phase: In late 2002 the system was converted to blend landfill gas with natural gas (50%/50%) to power one of two 1 MW Jenbacher 320 reciprocating engines (second engine is 100% natural gas-fired). Waste heat recovery from the engines provides thermal energy to the hotel and conference center.
- Uses 2,100 MMBtu/month of landfill gas.
- Second phase was an LMOP-assisted project.

Project Impact/Benefits

- Saves $10,000 to $15,000 per month in natural gas costs.

Source: U.S. Environmental Protection Agency, Landfill Methane Outreach Program. Includes information compiled from a December 2005 Waste Age article and the SCS Engineers Web site.

however, only the electricity generated is eligible for the tax credit.

Is Landfill-Gas-to-Energy in Your Future?

Are you interested in using landfill gas as an energy source? Don't know where to start? LMOP has a number of tools that can help determine if there could be a landfill in your future. The program offers technical support that includes finding a landfill, estimating gas generation and project economic analysis.

The first step is as simple as providing the plant address. From there LMOP can search a 5-, 10-, 15- or 20-mile radius to find the landfills near that facility. If you are a landfill searching for an end-user, LMOP can help find potential end-users in the same radius and model the gas generation using the EPA's LandGEM software. Then LMOP can compare the results to an end-user's energy demand and see if there is a good match.

Via its cost-analysis tool called LFGCost, LMOP can determine if a project might be a good investment. The cost tool provides economic data such as net present value, internal rate of return and years to payback. In addition, the tool estimates environmental benefits such as total amount of methane destroyed and the overall greenhouse gas emissions reductions. (More information on LMOP tools is available at www.epa.gov/lmop.)

Using landfill gas for energy is a win-win opportunity. Landfill gas energy projects involve citizens, nonprofit organizations, local governments and industry in sustainable community planning and creative partnerships. These projects go hand-in-hand with community and corporate commitments to cleaner air, renewable energy, economic development, improved public welfare and safety, and reductions in greenhouse gases that contribute to global warming. By linking communities with innovative ways to deal with their landfill gas, LMOP contributes to the creation of livable communities that enjoy increased environmental protection, better waste management and responsible community planning.

Rachel Goldstein is a program manager of the U.S. Environmental Protection Agency's Landfill Methane Outreach Program (LMOP), a voluntary program that encourages methane emissions reductions through the capture and beneficial use of landfill gas. Goldstein's primary roles are to manage the New England/Mid-Atlantic territory and LMOP's corporate outreach activities. Prior to joining the EPA, she spent 11 years in the environmental safety and health field. Goldstein, who holds a master of business administration degree, is on the board of directors for the Women's Council on Energy and Environment. She can be reached at Goldstein.Rachel@epamail.epa.gov.

Reprinted from Third Quarter 2006 District Energy magazine with permission of IDEA.